Time and Frequency:
Measurements and Applications
February 27th and 28th, 2006

Disneyland Hotel

Monday, February 27th

Part I – Introduction to Time and Frequency

7:00 - 8:00	Registration and Continental Breakfast	
8:00 - 9:30	Introductions and Course Overview	
	1a - Overview of Time and Frequency The Role of NIST Fundamentals and Basic Concepts Clocks and Oscillators Coordinated Universal Time (UTC) Time and Frequency Measurement Basics	(Lombardi)
9:30 - 10:00	Break	
10:00 - 10:45	1b - Overview of Time and Frequency Frequency Domain versus Time Domain Accuracy, Stability, Uncertainty Radio Reference Signals Traceability, Legal Metrology, and Accreditation	(Lombardi)
10:45 – 11:30	2 - Quartz Oscillators Oscillator Q How they work, and performance characteristics Oven Controlled Crystal Oscillators (OCXOs) Devices used as standards and time base oscillators Specifications of Commercially-Available Devices	(Novick)
11:30 – 12:30	Lunch	

Part II – Time and Frequency Measurements

12:30 – 1:15	3 - Basics of Measurement Instrumentation Oscilloscopes Universal Counters Signal Generators	(Graham)
1:15– 3:00	4 - Frequency Measurements Demonstration/Laboratory Using a Frequency Counter Using a Oscilloscope Using a Time Interval Counter Comparison and demonstration of methods	(All)

Hands-on Laboratory

3:00 - 3:30	Break	
3:30 – 3:45	Wrap-up of Measurement Demonstration/Laboratory	(All)
3:45 – 5:00	5 – Phase Comparisons / Time Domain Measurements Time Interval Counters Fundamentals of Phase Comparisons Resolution and noise of various systems Data Analysis	(Lombardi)

Reception for Seminar Participants, Monday Night, Details to be announced

Tuesday, February 28th

Part III – Data Analysis and Measurement Uncertainty

8:00 – 9:00	6 – Uncertainty Analysis Obtaining Average Time or Average Frequency Accuracy The role of stability statistics in uncertainty analysis - Allan deviation - Time deviation - Identifying types of noise - Removing noise by averaging Uncertainty Components - Type A - Type B GUM Examples for Calibration Reports	(Lombardi)

Part IV – Time and Frequency References and Standards

9:00 - 9:30	7a - Atomic Oscillators How they work Rubidium Oscillators Cesium Oscillators	(Novick)
9:30 - 10:00	Break	
10:00 – 10:30	7b – Atomic Oscillators Hydrogen Masers Specifications of Commercially Available Devices NIST-F1: Primary Standard for the United States Future Atomic Standards	(Novick)
10:30 – 11:00	8 – Time and Frequency Reference Signals Introduction to Time and Frequency Transfer Network, Skywave, Groundwave, Line-of-Sight, Satellites Time-of-Day and Precise Synchronization References Frequency References	(Lombardi)

11:00 – 11:30	9a – GPS and GPS Disciplined Oscillators Introduction to GPS The GPS Broadcast	(Lombardi)
11:30 - 12:30	Lunch	
12:30 – 1:45	9b – GPS and GPS Disciplined Oscillators GPS Disciplined Oscillator Performance Common-View GPS Measurements	(Lombardi)

Part V – Traceability, Legal Metrology, and Accreditation

1:45 – 2:30	10 - Stopwatch and Timer Calibrations Direct Comparison Method Time Base Method Totalize Method	(Graham)
2:30 - 3:00	11 - Establishing Traceability through NIST to the SI For low level applications For high level applications Traceability Models Uncertainty Comparison of Different Methods	(Lombardi)
3:00 - 3:30	Break	
3:30 - 4:00	12 – Legal and Technical Requirements Telecommunications Electric Power Industry Broadcasting	(Lombardi)
4:00 - 4:30	13 – NIST Remote Calibration Services Frequency Measurement and Analysis Service Time Measurement and Analysis Service	(Lombardi)
4:30 – 5:00	14 - Calibration Laboratory Requirements & Accreditation Equipment & Measurement Requirements for Cal Labs The accreditation experience ISO/IEC 17025 and Accreditation Role of traceability in laboratory accreditation	(Graham)